

UNIFIED DISPOSAL DISTRICT LANDFILL LANDFILL GAS MONITORING PLAN

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March 2008

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Waste & Underground
Tank Management Bureau

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UNIFIED DISPOSAL DISTRICT LANDFILL

LANDFILL GAS MONITORING PLAN

1.0 INTRODUCTION

The Unified Disposal District (UDD) Landfill (License #389) is located approximately ten miles east of Havre, Montana, south of U.S. Highway 2 and the Milk River (Figure 1-1). The legal location description is Section 1, Township 32N, Range 17E and Section 6, Township 32N Range 18E.

This document comprises the Landfill Gas Monitoring Plan (LGMP) for the UDD Landfill. The procedures outlined in the LGMP are consistent with Montana Department of Environmental Quality (MDEQ) requirements outlined in ARM 17.50.511, including specification of monitoring procedures, frequency, and reporting requirements, as well as maximum allowable concentrations of methane gas, as follows:

- The concentration of methane gas generated by the facility does not exceed 25% of the lower explosive limit (LEL) for methane in facility structures; and
- The concentration of methane gas does not exceed the LEL for methane at the facility property boundary.

The LEL for methane is 5%; therefore, the maximum allowable concentrations of methane gas in ARM 17.50.511 equate to 1.25% methane in facility structures, and 5% methane at monitoring locations at the facility property boundary.

2.0 GEOLOGICAL AND HYDROGEOLOGICAL CONDITIONS

The bedrock geologic map of the area (Sholes and Bergantino, 2002) shows the UDD Landfill site underlain by the Upper Cretaceous Judith River formation, described as a light-brown to yellow sandstone, siltstone, and white, yellow, greenish and light-gray claystone and shale. The formation is between 380 and 500 feet thick, with the sandstone beds generally lenticular and discontinuous in nature, and also contains thin coal beds in places (Lawlor, 2000).

The Milk River flows to the north and east about ½-mile north of the landfill, and Quaternary deposits of Milk River alluvium are present above the Judith River formation across the northwest portion of the site. Sholes and Bergantino (2002) also note that the bedrock throughout the vicinity of the UDD Landfill is concealed by Pleistocene-age glacial drift of “varying thickness and multiple origins.” Lawlor (2000) describes the glacial deposits as “consisting predominantly of unconsolidated gravel, sand, silt, and clay” and ranging in thickness from 20 to 100 feet.

Damschen & Associates (1991) excavated five test borings and thirty-three backhoe test pits as part of their initial hydrogeologic and soils investigation at the site. The logs from these borings and test pits confirm the presence of the glacial deposits in the landfill area, in thicknesses ranging from approximately 15 to 20 feet overlying sediments of the Judith River formation. The subsequent investigation (Damschen & Associates, 1993) also identified a thin, water-bearing wedge of glacial sand and gravelly sand adjacent to the southern end of the landfill.

Three landfill gas monitoring wells (MG-1, MG-2, and MG-3) have been installed at the UDD Landfill site for gas monitoring purposes. Wells MG-1 and MG-2 are dual completions, consisting of two risers screened at different depth intervals. Well locations are shown on Figure 2-1. Copies of the lithologic and completion logs for the landfill gas monitoring wells could not be located despite a thorough search of the MDEQ project files.

3.0 METHODS

This section of the landfill gas monitoring plan for the UDD Landfill outlines the monitoring locations and frequency, and the methods and equipment that will be used to conduct routine landfill gas monitoring at the site.

3.1 MONITORING LOCATIONS

Landfill gas monitoring locations are shown on Figure 2-1, and include three gas monitoring wells (MG-1, MG-2, and MG-3), as well as the office building at the entrance to the landfill. If any additional structures are built at the facility such that methane could accumulate within the structures, these structures will be added to the landfill gas monitoring program.

In accordance with the initial landfill gas monitoring plan (Damschen & Associates, 1994), the landfill gas monitoring wells at the UDD Landfill were installed to target permeable sand beds within the glacial drift and underlying Judith River formation. Wells were constructed with 1.25-inch diameter Schedule 80 PVC, with hand-cut slots (approximately 0.025-inch) in the screened intervals. The annular space around the screened interval is completed with a coarse sand/gravel pack, while the upper portion of the PVC is grouted in place with hydrated bentonite from the ground surface to just above the screened interval. Bentonite was also placed between the screened intervals in the multiple completion wells. Wells are equipped with steel protective surface casing with locking lid, and the top of the PVC casing is fitted with a PVC cap and valved sampling port. A schematic drawing of typical completion details is in Appendix A.

3.2 MONITORING FREQUENCY

Concentrations of methane, carbon dioxide, and oxygen (reported as % of total) will be measured in each of the gas monitoring wells and the office building (Figure 2-1) on a quarterly basis, in accordance with ARM 17.50.511.

3.3 MONITORING EQUIPMENT AND PROCEDURES

Landfill gas concentrations will be measured in each gas monitoring well using a Gas Data LMSx MultiGas Analyzer. This instrument is factory-calibrated and serviced annually by CEA Instruments, Inc. in Emerton, New Jersey (information available at <http://www.ceainstr.com/about.html>). Selected portions of the LMSx User Manual are included with this monitoring plan in Appendix B (Section 5.0 – General Operation and Section 7.0 – Field Operation). In the event that the LMSx instrument malfunctions or is otherwise unavailable for monitoring, alternative instrumentation may be substituted for measuring landfill gas concentrations, provided that the selected instrument is capable of reporting concentrations of methane, carbon dioxide, and oxygen, and that verification of instrument calibration is available.

Landfill gas concentrations will be measured directly in each landfill gas monitoring well by connecting the gas analyzer inflow port to the valved sampling port on the monitoring well, opening the valve, and drawing gas through the instrument by engaging the sampling pump. Gas concentrations in ambient air within the office building will be measured immediately upon entrance.

3.4 DOCUMENTATION AND REPORTING

Instrument readings measured at each monitoring location will be recorded on a Methane Monitoring Field Data sheet (Appendix C). Information to be included on the data sheet will include the facility ID, date and time, sampling personnel conducting the monitoring, weather conditions, and percent methane, carbon dioxide, and oxygen levels at each monitoring location.

Landfill gas monitoring results for the UDD Landfill, consisting of copies of completed field data sheets, will be placed in the facility operating record and submitted to MDEQ following completion of each quarterly monitoring event. In addition, an annual landfill gas monitoring summary for a calendar year will be submitted to MDEQ in January of the following year. The annual summary will consist of tabulated results for each monitoring site for each

quarter, along with a narrative description of the annual results in an accompanying cover letter.

In the event that methane concentrations are detected that exceed the limits specified in ARM 17.50.511(1)(f) (i.e., 25% of the methane LEL in structures and 100% of the methane LEL in gas monitoring wells near the property boundary), additional reporting and actions will occur in accordance with ARM 17.50.511(1)(h), including:

- Taking immediate action to ensure the protection of human health (e.g. notifying landfill personnel, evacuating buildings if necessary);
- Notifying MDEQ within 7 days of the methane levels detected, and of steps implemented to protect human health; and
- Implementing within 60 days an MDEQ-approved remediation plan for the methane gas releases.

Previous monitoring of landfill gas at the site has shown elevated methane concentrations at locations MG-1A/B and MG-2A/B; concentrations in 2006 at these wells ranged from 0 to 32.5% methane (Barry Damschen Consulting, 2007). However, since the wells in questions are located a considerable distance from site buildings and from the property line, no response actions have been required at this time.

4.0 REFERENCES

- Barry Damschen Consulting, LLC, 2007. Letter to Mary Louise Hendrickson (MDEQ) dated January 10, 2007 regarding 2006 methane monitoring results for Unified Disposal District Landfill.
- Damschen & Associates, 1994. Landfill Methane Monitoring Plan for The Unified Disposal District Landfill. April 1994.
- Damschen & Associates, 1993. Additional Hydrogeological and Soils Analysis of the Unified Disposal District Landfill, Havre, Montana. October 1993.
- Damschen & Associates, 1991. Hydrogeologic Analysis for the Existing Sanitary Landfill. Prepared for Unified Disposal District, Havre, Montana. October 1991.
- Lawlor, S.M., 2000. Hydrologic and Water-Quality Data for Ground Water along the Milk River Valley, North-Central to Northeastern Montana. USGS Open-File Report 00-79. April 2000.
- Sholes, M.A. and R.N. Bergantino, 2002. Geologic Map of the Havre 30' × 60' Quadrangle, North-Central Montana. Montana Bureau of Mines and Geology Open File Report 467.

FIGURES



2005 NAIP aerial photo and approximate property boundary from Montana NRIS

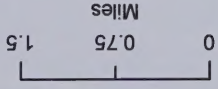


Figure 1-1
Unified Disposal District Landfill
General Location Map



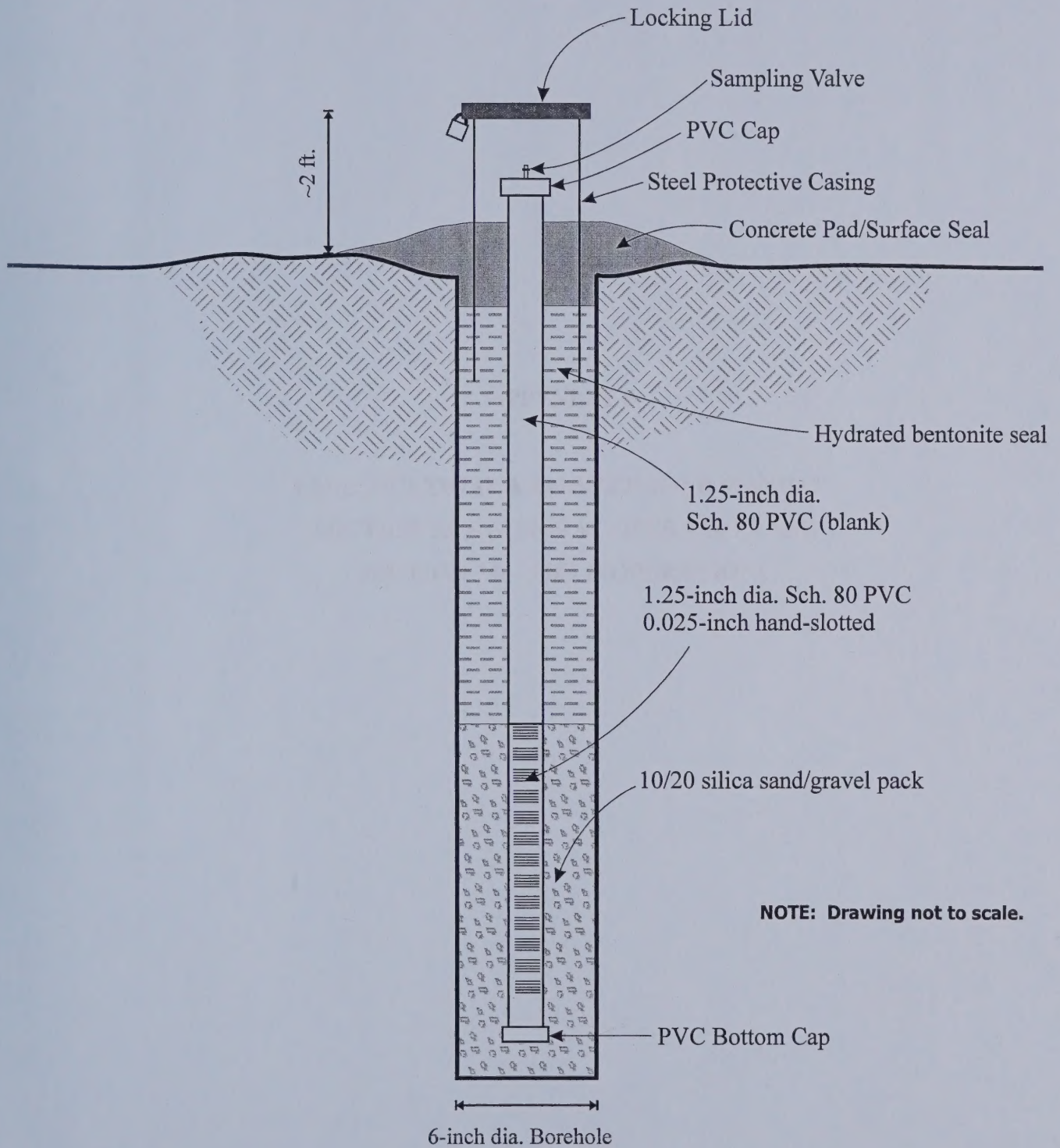
2005 NAIP aerial photo obtained from Montana NRIS

Figure 2-1
Landfill Gas Monitoring Locations
Unified Disposal District Landfill

APPENDIX A

UNIFIED DISPOSAL DISTRICT LANDFILL

TYPICAL LANDFILL GAS MONITORING WELL SCHEMATIC DRAWING



**TYPICAL LANDFILL GAS
MONITORING WELL SCHEMATIC**

APPENDIX B

LMSx MULTIGAS ANALYZER USER MANUAL (SECTION 5.0 – GENERAL OPERATION AND SECTION 7.0 – FIELD OPERATION)

4. Manual input (readings read from another instrument(s)). (NOT IMPLEMENTED at time of writing)
5. External sensors connected via the RS232 interface. (NOT IMPLEMENTED at time of writing)

Flow readings displayed are calculated using the current values set. If different settings are required at different measurement locations then the settings must be changed prior to the readings being taken. Changing the settings will not of course change the values of flows already stored.

The flow device setting screen is entered by pressing and holding either the next or previous key for about a second. Release the key as soon as the screen changes;

F	l	o	w	D	e	v	i	c	e	O	r	i	f	i	c	e				
			P	i	p	e	D	1	0	0			c	m						
O	r	i	f	i	c	e	D		1	0			c	m						
			T	e	m	p		2	5	0		C								

p

Initially the cursor will be on the Flow Device setting, use the next and previous keys to select the required type. Press the confirm key to move to the next field.

Use the numeric keys to enter the data for pipe dimensions (see TIP on changing units below), calibration factors and default gas temperature.

TIP The temperature setting is the gas temperature that will be assumed by the instrument if there is no valid input from the external temperature probe.

TIP If a mistake is made entering the numbers simply press 0 (zero) repeatedly until the field clears, then type the numbers required.

TIP The units for dimensions can be chosen from mm, cm and inches independently of any units set in the main Select Engineering units screen. The units are changed by using the next or previous keys when the cursor is within the units field. To get the highest resolution it may be necessary to use mm for all dimensions even though the preferred units may be inches or cm. (Remember: 1 inch = 2.54 cm = 25.4 mm)

TIP Orifice plates require a Co value to be given. This is often referred to as the 'discharge coefficient' and will be known by your orifice plate manufacturer. Consult them if necessary.

TIP For Pitot tubes the 'K' factor will be specified by the manufacturer. Most high quality pitot tubes are designed to yield K factors of between 0.980 and 1.020 therefore in practice a setting of 1.000 will give less than 2% error.

5.0 General Operation

The following section is designed to be a rapid run through the operation of the unit, and does not detail all possible screen displays and situations which can arise. In particular, it assumes that the unit will be in a factory supplied state, with no stored readings and no site and bore holes identifiers set.

5.1 Power On

Press the power key to turn the unit on.

A short beep will sound and the display will show the Gas Data banner as follows :

				G	a	s		D	a	t	a		L	t	d					
								L	a	n	d		f	i	l	i				
				M	o	n	i	t	o	r	i	n	g		S	y	s	t	e	m

After two seconds this will clear and the intrinsic safety warning banner (below) will be displayed. This banner will be displayed until a key is pressed.

		T	h	i	s	U	n	i	t	i	s							
		n	o	t	c	e	r	t	i	f	i	e	d					
		i	n	t	r	i	n	s	i	c	a	l	l	y	s	a	f	e
		-	s	e	e	m	a	n	u	a	l	-						

Pressing any key (apart from the power key !) will then advance the unit to the main gas reading display mode. The unit requires 30 seconds settling time after power up before the gas readings are valid, and the unit will show blank fields during this period.

5.2 Main Display

C	H	4	:	x	x		x	%		C	O	2	:	y	y		y	%	
O	2			z	z		z	%		a	P			a	a	a	a	m	b
T	m	p		t	t		t	C		d	P			d	d		d	m	b
S	t			s	s	s	s	s	s	s	B	H		b0	b	b	b		

The display shows the gas sensor readings. A typical screen is shown above. For an instrument with expansion options fitted (other gases, flows, pressures etc.) the screens will vary and may be spread over more than one screen. Second screens are accessed by pressing the Next or Previous keys. These fields will be blanked out for the first thirty seconds after power on, while the unit stabilises. Then readings are displayed along with their appropriate units. The bottom line of the display shows the currently selected site and bore hole codes (if set). All keys behave like function keys in this mode, and the actions of the keys from this starting display are described in subsequent sections.

5.3 Optional Multi Gas Expansion

The following section details the changes LMSx that result from multiple toxic gas additions. The second readings screen (shown below) is obtained by pressing either the Next or Previous

key.

	H	2	S			C	O			H	C	L			L	E	L
x	x	x	x			x	x	x	x		x	x	x	x		x	x
	p	p	m			p	p	m			p	p	m			%	
S	t		s	s	s	s	s	s	s		B	H		b0	b	b	b

The fields will be blanked out for the first thirty seconds after power on, while the unit stabilises. The actual gas channel readings displayed will depend on the sensors fitted in your instrument (specified at purchase) and may not be exactly as shown above.

NOTE: Single gas expansions may be possible without the addition of the second screen. This will depend upon the configuration of the other non-gas channels fitted eg temperature and pressure etc.

5.4 Optional Low Range Bore Hole Flow and Pressure Measurement

The initial main gas display mode is replaced with the gas flow rate display screen as shown :-

			F	l	o	w		0	0	l	/	h	r						
a	P	l	0	l	5		m	b			d	P	0	0	P	a			
	c	r	o	s	s		t	o		h	o	l	d		f	l	o	w	
S	t		-	-	-	-	-	-	-	-	B	H							

The flow reading can be held by pressing the cross key, or by toggling to the standard gas display screen (see below). Once held, the message changes to "tick for live flow" and the flow reading can be made live once more by pressing the tick key.

Press the next or previous keys to toggle between this screen and the standard main gas display screen. The main gas display screen will also be selected when the pump is turned on.

C	H	4			0	0	%			C	O	2			0	0	%		
O	2		2	0		1	%			L	E	L			0	0		%	
T	m	p	<	<	<	<	C												
S	t		-	-	-	-	-	-	-	-	B	H							

With either of these screens displayed, the keys will behave as function keys as described in the main manual. e.g. pressing key 1 will store readings etc.

NOTE: When viewing readings, the stored gas readings screen is displayed first, toggle to the stored flow readings screen using the next and previous buttons. The user entered status and depth to water fields are found on this screen.

5.5 Optional Gas Extraction Flow Measurement - LMSx +F

This instrument configuration is always based upon two screens. The first, 'gas readings' screen is as follows;

C	H	4		x	x		x	%			C	O	2		y	y		y	%
O	2			z	z		z	%			N	2			n	n		n	%
T	m	p		t	t		t	C											
S	t			s	s	s	s	s	s	s	B	H			b	b	b	b	

The gas readings are the values of CH₄, CO₂ and O₂ gas are as analysed. The N₂ gas value is the calculated as the subtraction of CH₄, CO₂ and O₂ from 100% i.e. it represents the balance.

TIP The gas readings are only analysed and updated whilst the pump is ON. They are retained whilst the flow readings are viewed. These are the gas values which are used by the flow calculations to determine gas density and calorific value.

The second 'Flow readings' screen is as follows. It is viewed by momentarily pressing either the next or previous keys. Press them once again to leave the screen.

a	P			1	0	2	5	m	b		F			1	5	m	3	/	h
d	P				0		3	m	b		N	2			n	n		n	%
s	P				-	2	6	m	b										
P	o	w	e	r						1	0	0	K	W					

TIP These readings are only analysed and updated when the pump is OFF. Switching to this screen will automatically switch the pump OFF.

The channels are defined as follows;

aP	Pressure at inlet (Static) port of analyser. When the Zero key is pressed the value of this channel is stored internally to allow the sP channel to be calculated (See sP below). This must be done before connecting sample lines to the wellhead so that the value stored is equal to the current atmospheric pressure.
dP	The differential pressure between the inlet (Static) port and outlet (Impact) port of the analyser. This will now equal the pressure due to gas flow past the pitot tube or orifice plate.
sP	This is the Static Pressure or Suction pressure or Vacuum. It is calculated as the difference between the value stored as atmospheric pressure and the current pressure applied to the inlet (Static) port of the analyser.
Power	This is the theoretical power output of the gas well. It is calculated from the product of the calorific value of the gas and the flow rate.
F	This is the volumetric flow rate of the gas at the well. It is calculated from the dP value and takes into account the flow device dimensions/calibration factors and the gas density. (Composition, pressure and temperature)

5.6 Gas Sampling

5.6.1 Standard Instrument

The sample pipe with in line PTFE filter is connect to the top port on the side of the instrument labelled IN

Pressing the pump key will start the gas sampling pump. Gas will be sucked in through the inlet connector (Top connector on the right hand side of the unit), through the sampling chamber and out of the exhaust connector. (Bottom connector on the right hand side of the unit The pump will run until the pump key is pressed again.

See also section on Field Operation

5.6.2 Gas Sampling with Low Range Bore Hole Flow option fitted

If the optional low range bore hole pressure and flow expansion is fitted the top connector labelled IN is used to connect the sample pipe with in line PTFE filter. The bottom connector labelled OUT is then used as the flow measurement port. The sample line is connected **WITHOUT** the in line PTFE filter to avoid pressure loss.

The exhaust exit for the sample gas is a small aperture between the top and bottom ports.

See also section on Field Operation

5.6.3 Gas Sampling with Gas Extraction Flow Measurement - LMSx +F

The top port of the instrument, the inlet (Static) port, is connected to the sample pipe with in line PTFE filter. The bottom (Impact) port is connected to a sample pipe with no filters. The diagrams below show the connections to Orifice plates and Pitot tube flow devices.

TIP When connecting to a well head in the field and the connections are unclear or ambiguous connect the pipes first one way then the other. The correct way around will always yield the highest value of dP (ignore the sign of dP).

See also section on Field Operation.

5.7 Power Off

Pressing the power key with the unit turned on will turn the unit off. There is a short delay after pressing this key before the power is fully off, during which the unit checks the integrity of the internal memory. If an error is detected the screen will report the "Memory Corrupt" message and because the readings contain errors they will be discarded. This event should only happen as a result of an equipment fault.

5.8 Storing Readings

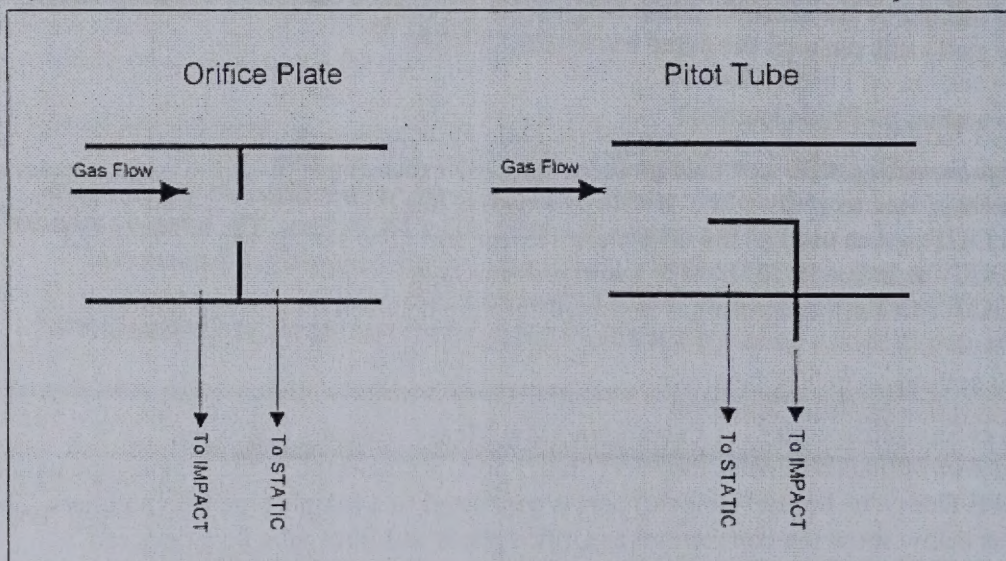
5.8.1 Standard Instrument

See also section on optional Site Manager program

Pressing the store key initiates the reading save function. You are required to confirm the site and bore hole codes that you wish the reading to be filed under. The following display allows you to do this :

S	t	o	r	i	n	g	R	e	a	d	i	n	g	s	a	t
		S	i	t	e	=	-	-	-	-	-	-	-	-	-	-
				B	H	=									O	K ?

Initially the site and bore hole identifier fields will be blank, as shown above and you must



enter some values before you can save the readings. Pressing the cancel key allows you to set

the site and bore hole code by first presenting the site entry menu.

C	h	o	o	s	e		s	i	t	e		n	a	m	e				
		S	i	t	e	=	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Again, initially all fields will be blank. Later all the dashed fields may show previously entered site names or identifiers. Pressing the cancel key now will return you to the main reading display, without saving the readings. Using any numeric keys will edit the site field at the top of the display E.g. type '1234' and the site = field will change to 1234. If any of the fields at the bottom of the display are not blank, (i.e. site codes have been previously entered) then pressing the next and previous keys will select these codes, with the currently selected code shown in the field at the top of the display. Press the confirm key to finish entering the site code, and take you to the bore hole entry menu.

C	h	o	o	s	e		B	H		c	o	d	e						
				B	H	=													

As shown, all fields will be initially blank, but will show previously entered bore hole identifiers for the given site after these have been entered. Pressing the cancel key now would take you back to the site entry menu. Using any numeric keys will edit the bore hole field at the top of the display e.g. type '999' and the "BAH =" field will change to 999. If any of the fields in the lower half of the display are not blank (i.e. BH numbers have been previously entered) then pressing the next and previous arrow keys will select these codes, with the selected one shown opposite the "BH =" message. Press the confirm key to return you to the storing readings menu which will now show the site and bore hole identifiers you have entered.

		S	t	o	r	i	n	g		R	e	a	d	i	n	g	s		a	t
		S	i	t	e	=		1	2	3	4									
		B	H	=				9	9	9								O	K	

Press the confirm or the store key now to finally store the gas readings filed under Site code 1234 and bore hole number 999, and return to the main gas display. If either the Site or BH fields are blank, pressing the confirm or store key will have no effect.

If you did not wish to store the readings under this site and bore hole, pressing the cancel key will return you to the main gas display without saving the readings. Or you may select another bore hole code at this site by using the next and previous keys.

5.8.2 Storing Readings on Extraction Flow Measurement Instruments - LMSx +F

Follow the instructions as above with the following exception.

When a store sequence is started, the instrument will prompt you for a bore hole status code. Use the next and previous keys to select the value from the list followed by the confirm key to proceed with the store sequence as above.

5.8.3 Storing Manual Measurement Values (Flow rate, depth to water, bore hole status) - Standard Instruments Only

See also section on Viewing Stored Readings

First use the View key to and choose the correct stored reading to which you wish to attach manual reading values. (See Viewing Stored Readings below)

Press the Store key from this to proceed to the manual parameters edit screen.

The manual parameters screen appears as follows :

[illegible]

Initially the flashing edit cursor appears to the right of the flow figure. use the numeric keys to enter a new value into this field. If you make a mistake, press the zero key until the figure returns to 0, then type again the value require.

Move to the next editable field (the flow units) by pressing the confirm key. This is a multiple choice field (as is the status field) indicated by the cursor being on top of the field. Use the next or previous keys to change the selection (between m3/Hr, cfm and l/h) and again move to the next editable field by pressing the confirm key.

Pressing confirm after setting the last editable field (the status code) will return you to the view readings menu shown above.

Press the cancel key whilst editing any of these manually entered fields to return you to the view readings menu, abandoning any changes you may have made.

To toggle the status code between the stored list of standard parameters press the next and previous keys.

Use the numeric keys to set the flow to the value indicated by your external instrument, and press the confirm key again to continue to the flow units parameter. The selections m3/h, cfm and l/h are selected with the next and previous keys as for the status code described above. Press the confirm key again to continue to the store confirm screen.

5.9 Viewing stored readings

Pressing the view key allows you to display readings previously stored, and add some extra parameters to the stored reading. These extra parameters include a selection of bore hole status codes, a depth to water reading and a gas flow measurement. These parameters are taken using other instruments and entered into the LMSx for convenience of handling the data back in the office.

Initially, the view confirmation menu is presented

	V	i	e	w	R	e	a	d	i	n	g	s	f	o	r
	S	i	t	e	=	1	2	3	4						
	B	H	=		9	9	9			O	K	?			

Pressing the confirm key will then take you to the view readings screen, as shown. Alternatively the next and previous keys may be used to select a different BH code prior to viewing the readings, or the cancel key may be pressed to select a different site entirely (see under Deleting stored readings for the sequence of menus if you want to try this).

The stored readings are typically displayed in the following form :

C	H	4		0	0	%		C	O	2		0	0	%				
O	2		1	1	7	%	a	P		1	0	2	3	m	b			
T	m	p	2	1	3	C	d	P		9		3	m	b				
3	0	/	J	u	n	/	9	4		1	5		4	2	b	b	b	b

This form is similar to the display on the main menu, but it also shows the time and date the reading was stored in the lower left corner of the display, and it only shows the bore hole code, and not the site.

Press the Previous key to view older readings if any exist, and use the Next key to return to the later readings.

NOTE: These screens vary depending upon the number of optional channels fitted. The readings may be spread across more than one screen. To view other channels on other screens press the Next key. Press and hold the previous key to view older readings if any exist, and press and hold the next key to return to the later readings.

5.10 Deleting stored readings

5.10.1 Deleting Single Readings

WARNING: Deleted readings can NEVER be recovered

Pressing the delete key allows you to first display and then optionally delete readings previously saved. It is possible to delete single readings, all readings for any bore hole or all readings for a complete site. You must first select which site and bore hole you wish to delete the stored readings for, so first the site selection menu is presented.

[illegible]

The four entries at the bottom of the display will show the names of previously entered sites. It is possible to scroll through the site names if more than four exist, using the arrow keys. The entry at the top of the display "sssssss" shows which site is currently selected.

Use the Next and Previous keys to select which site you wish to view the readings for. Press the confirm key to proceed to the bore hole selection menu. Alternatively, press the delete key and see the section below "deleting an entire site".

C	h	o	o	s	e		B	H		c	o	d	e						
							B	H	=	b	b	b	b						

Use the Next or Previous keys to select which bore hole you wish to view the readings for, then press confirm to proceed. Alternatively, press the delete key and see the section below "deleting an entire bore hole".

If any readings have been saved under the selected site and bore hole, the display will now change to show the most recently stored reading in the form described under Viewing stored readings above. Reproduced here :

C	H	4			0		0	%		C	O	2			0		0	%	
O	2		1	1		7	%		a	P		1	0	2	3	m	b		
T	m	p	2	1		3	C		d	P		9		3	m	b			
3	0	/	J	u	n	/	9	4		1	5		4	2		b	b	b	b

Press the cancel key when you have finished and wish to return to the main display or press the delete key to delete the displayed reading, whereupon the following confirmation prompt is displayed :

	D	e	l	e	t	e		R	e	a	d	i	n	g					
	S	i	t	e				s	s	s	s	s	s	s	s				
							B	H			b	b	b	b			O	K	?
	1	5	/	S	e	p	/	9	2		1	1		4	2		5	1	

The site and bore hole entries show which site and bore hole the reading you have selected belong to, and the date stamp indicates which reading you are about to remove from the unit. Press the confirm key now if you really want to delete the reading, or press cancel if you do not. Either way, the viewing of stored readings will then resume.

5.10.2 Deleting an entire Site

WARNING: Deleted readings can NEVER be recovered

An entire site may be deleted by pressing the delete key from the site selection menu as described above under "Viewing and Deleting Stored Readings". You must first select the site

you wish to delete. The following confirmation prompt will then be displayed :

	D	e	l	e	t	e		A	L	L		r	e	a	d	i	n	g	s	
	F	o	r		S	i	t	e				s	s	s	s	s	s	s	s	
																			O	K ?

Press confirm to proceed with the site deletion. All readings, bore hole numbers and the site name of the selected site will be removed from the units memory. Press cancel if this is not intended. You will then be returned to the site selection menu and can select another site for deletion, or proceed to select bore holes.

5.10.3 Deleting an entire Bore hole

WARNING: Deleted readings can NEVER be recovered

All readings for a single bore hole may be deleted by pressing the delete key from the bore hole selection menu as described above under "*Viewing and Deleting Stored Readings*". You must first select the site and bore hole you wish to delete. The following confirmation prompt will then be displayed.

	D	e	l	e	t	e		R	e	a	d	i	n	g	s		F	o	r	
	S	i	t	e				s	s	s	s	s	s	s	s					
	B	H						b	b	b	b									
																			O	K ?

Again, press confirm to proceed with the bore hole deletion. All readings and the bore hole number of the selected site and bore hole will be removed from the units memory. Press cancel if this is not intended. You will then be returned to the bore hole selection menu and can select another bore hole for deletion, or proceed to view and delete readings.

5.10.4 Deleting ALL Readings within the Instrument

WARNING: Deleted readings can NEVER be recovered

There is a shortcut function to allow ALL readings i.e. ALL SITES and ALL BORE HOLES.

Switch the unit off. Press and hold the Delete key and keep this key pressed whilst switching the unit back on. Keep the delete key pressed until the instrument is heard to beep. The following screen will appear:

		P	r	e	s	s		C	o	n	f	i	r	m		t	o			
		D	e	l	e	t	e		A	L	L		s	t	o	r	e	d		
								R	e	a	d	i	n	g	s					
																			O	K ?

Press the Confirm key to proceed with the deletion of ALL readings or press the Cancel key to abort.

WARNING: Deleted readings can NEVER be recovered.

5.11 Printing Stored Readings

Readings which have been stored may be printed on a printer connected by a serial cable from the connector on the units front panel. The printer used must support serial RS232 communications, and a suitable connecting lead must be available. The printer will need to be set for hardware handshake, 9600 Baud, no parity, 8 data bits and 1 stop bit.

NOTE:

It is also possible to download readings into a computer, using the optional cable and 'SiteMan' program. Then use a printer attached to the computer to print the readings. **THIS IS THE PREFERRED METHOD OF READING PRINT OUT.**

If the print key is used on the unit to initiate the sending of the readings. All readings can be sent for an entire site, a group of sites, a single bore hole or a group of bore holes. The following display enables you to select the sites you wish to print :

F	r	o	m	S	i	t	e	=	s	s	s	s	s	s	s	s	s
		T	o	S	i	t	e	=	S	S	S	S	S	S	S	S	S
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Initially, pressing the Next or Previous keys will cause the selected 'from site' entry "sssssss" to change. Press the confirm key when you have the first site selected. Now the 'to site' entry "SSSSSSSS" will change as you use the Next or Previous. Again press the confirm key when you have selected the final site you wish to print. If you have more than one site selected, printing will now commence, otherwise you will be required to choose which bore holes for the selected site you wish to print, and the following display allows this.

F	r	o	m	B	H	=	b	b	b	b							
		T	o	B	H	=	B	B	B	B							

Similarly, at first using the Next or Previous keys will cause the 'From BH' entry "bbbb" to change. Then after pressing the confirm key the 'To BH' entry will update. When the appropriate range of bore holes has been selected, pressing the confirm key again will start the printing. Readings will be sent from the unit in a formatted fashion. During this process the following display will show progress:

P	r	i	n	t	i	n	g										
				S	i	t	e		s	s	s	s	s	s	s	s	s
				B	H				b	b	b	b					

The site and bore hole fields will be updated as readings are sent to the printer. If they do not change, or do not appear at all, then there is a fault with the cable or printer. The printer may be off-line, or the cable faulty or incorrectly wired. Hold the cancel key (for about a second) to abort the print operation if this happens.

The results will be typically be printed in the following form depending upon the number and type of optional expansion channels fitted :-

```

site : Coventry
BH: 1
CH4 , CO2 , O2 , Tmp , aP , dP , sP , Flw , , Stat, date , time
% , % , % , °C , mb , mb , mb , F
20.3 , 11.6 , 7.8 , 10.4 , 1020 , 2.1 , 31 , ---- , cm/s , OK , 1/07/94 , 9:04:05
18.7 , 1.5 , 9.7 , 12.6 , 1024 , 3.2 , 23 , 1234 , cm/s , OK , 19/06/94 , 10:30:58
15.3 , 12.3 , 9.3 , 15.1 , 1011 , 4.2 , 21 , ---- , cm/s , OK , 21/05/94 , 11:02:44

```

```

BH: B1
CH4 , CO2 , O2 , Tmp , aP , dP , sP , Flw , , Stat, date , time
% , % , % , °C , mb , mb , mb , F
9.5 , 11.6 , 12.1 , 13.5 , 1020 , 0.2 , 1 , ---- , cm/s , OK , 1/07/94 , 9:04:07
12.1 , 9.2 , 13.4 , 15.0 , 1023 , 1.7 , 3 , ---- , cm/s , LOST, 19/06/94 , 10:45:55
13.6 , 8.1 , 9.0 , 16.4 , 1010 , 2.6 , 2 , ---- , cm/s , DMGD, 21/05/94 , 11:06:53

```

```

BH: A2
CH4 , CO2 , O2 , Tmp , aP , dP , sP , Flw , , Stat, date , time
% , % , % , °C , mb , mb , mb , F
65.7 , 1.6 , 1.5 , 13.7 , 1020 , 2.1 , 101 , ---- , cm/s , OK , 1/07/94 , 9:04:09
63.5 , 1.3 , 1.0 , 14.9 , 1023 , 1.5 , 78 , ---- , cm/s , OK , 19/06/94 , 10:06:53
70.3 , 1.1 , 0.5 , 16.8 , 1023 , 3.0 , 91 , ---- , cm/s , OK , 21/05/94 , 11:02:55

```

5.12 Data Logging

The unit has a built in unattended data logging facility. It can be left to automatically take readings at fixed intervals for any given time period.

It is possible to set the unit into auto logging mode at sample intervals of 120 samples per hour down to 1 sample per hour, and for periods from 1 hour up to about 1200 hours.

To configure and start the data logging press the timer key. The display will then show the data log set up screen below.

				D	a	t	a	L	o	g	g	i	n	g				
R	a	t	e					0		/	H	r						
F	o	r						2	4		H	r	s					
P	u	m	p		F	o	r				1	0			S	e	c	s

The 'Rate' is the number of readings to take per hour. Initially the cursor will be on this value. Pressing the number keys will change the rate. Larger numbers than the maximum rate of 120 samples per hour can be entered, but they will be taken to be the maximum rate. Press the confirm key to proceed to the next 'For' field.

The 'For' field is the length of time data logging will last in hours. The total number of readings to be taken will thus be the product of the 'Rate' and 'For' fields. The limit on this field is thus dependant upon how many free reading slots are available (see 'Status display' section below), and how fast a logging rate has been selected. As before enter a new value using the number keys, and press the confirm key to proceed.

If you make an error while entering a numeric value, pressing the zero key a few times will return the field to zero, and you may then re-enter the number you want. Previous fields may be selected using the Previous key and fields may be skipped using the next key. The final field on this display is 'Pump For' which is the length of time the internal pump will run before storing each data logged reading. Pressing the confirm key on this field will then take you to the log data confirmation display, which allows you to confirm or change the site and bore hole codes.

L	o	g	g	i	n	g	R	e	a	d	i	n	g	s	t	o
S	i	t	e	=	s	s	s	s	s	s	s	s	s	s		
		B	H	=	b	b	b	b	b							

On this display "ssssssss" and "bbbb" are the currently selected site and bore hole identifiers. Press the cancel key to change these as described in the 'storing readings' section above or press the confirm key to turn the unit off and begin the logging operation. During data logging the unit will turn itself on at regular intervals as set in the data log set up screen above, and will display the following:

l	o	g	g	i	n	g	r	e	a	d	i	n	g			
n	n	n	n	/	m	m	m	m								
W	a	r	m	U	p											

where 'nnnn' is the log number, and 'mmmm' is the total number of readings to be taken. After a few seconds the display will change to :-

l	o	g	g	i	n	g	r	e	a	d	i	n	g			
n	n	n	n	/	m	m	m	m								
P	u	m	p	i	n	g										

and the pump will start. After the pump on period set, the pump will turn off, the current readings will be saved, and the unit will turn off.

If you try to turn the unit on while data logging is set, you will be warned that data logging is set, and given the opportunity to cancel the data logging function with the following display.

				!	W	a	r	n	i	n	g	!				
		P	r	e	s	s	c	o	n	f	i	r	m	k	e	y
		t	o	s	t	o	p	I	o	g	g	i	n	g		

Pressing any key other than the confirm key will cause the unit to turn off and data logging will resume. Pressing the confirm key will cause the data logging operation to be cancelled, and the normal start up sequence will begin.

5.13 Battery Voltage, Display Contrast and Free Memory

A number of miscellaneous parameters are collected together under the status display accessed by pressing the status key. The following shows the format of the status display.

S	t	a	t	u	s	.													
		B	a	t	t	e	r	y	1	2	6	V							
		C	o	n	t	r	a	s	t	1	2	8							
	1	1	6	8	S	t	o	r	e	s	f	r	e	e					

The three items on this display are battery voltage, display contrast setting and the number of reading stores which are currently free.

5.13.1 Checking Battery Voltage

The battery voltage is displayed directly. Whilst still on charge and at the end of a full charge period (Approx. 12 Hours) the battery voltage will be approximately 13.8 to 14.0 V. When the battery charger is removed the battery voltage will settle to approximately 12.6 to 12.8 V. This indicates a full battery charge.

Various battery voltages and likely capacities are summarised below:

Battery Volts	Conditions	Likely Capacity Remaining
13.8 to 14.0	Connected to charger after extended charge period (6 to 14 hours depending upon previous level of discharge)	90 to 100%
12.6 to 12.8	Not connected to charger, pump running	90 to 100%
12.0 to 12.2 V	Not connected to charger, pump running	30 to 50%
11.8 to 12.0	Not connected to charger, pump running	10 to 20%
11.5 and below	Not connected to charger, pump running	0%

TIP When checking battery voltage, switch on the pump for a few seconds to get the 'worst case' reading before making a judgement about remaining battery charge.

TIP When connecting an instrument for charging, switch the unit on and observe the battery voltage. If the charger is successfully connected and operating correctly the battery voltage will be seen to rise by 0.1 to 0.2 V over a short period of about 30 to 60 seconds. If this does not occur, leave on charge for approximately 10 minutes. After this period the battery voltage should have risen by at least 0.5 V. If this does not happen it is likely that there is a problem.

5.13.2 Checking Free Memory

A reading store can hold the data for one set of readings. A set of readings is one value for every channel which is fitted plus the time (to the nearest second) and date that reading set was taken. In addition some storage space is required for the site names and bore hole identifiers.

As a rough guide a site name takes about the same amount of storage space as a set of readings, and a bore hole identifier about half that.

Thus if the status display shows 350 stores free, either 350 readings could be taken under an existing site and bore hole identifier or ten new site names and a hundred new bore hole identifiers could be added, in which case it would leave about enough storage space for about 290 actual reading sets.

5.13.3 Adjusting Screen Contrast

The contrast setting may be changed by pressing and holding either the next or previous keys down. During this process, the display contrast will be seen to change, and the contrast number will vary between 0 (lightest) and 255 (darkest).

6.0 Data Upload and Download - Optional Site Manager PC Software

6.1 Principle of operation

Site Manager software provides a convenient framework to allow your PC to interact with the Gas Data LMSx instrument.

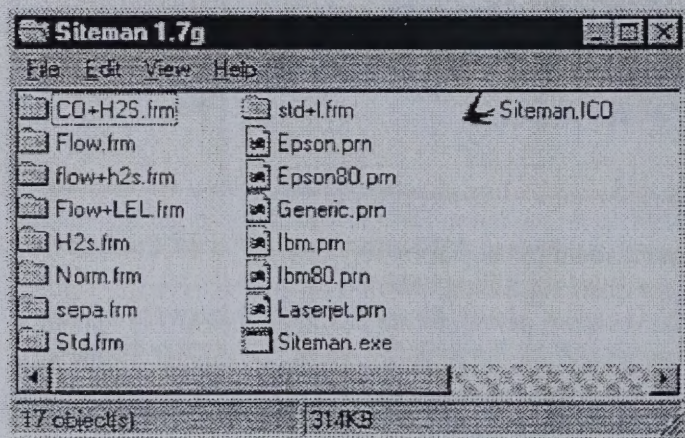
It provides the following functionality

- Preparation of site description files, containing a site name and a list of bore hole codes.
- Download of site description files to the LMSx prior to a site visit.
- Upload of readings (from the LMSx) taken at a site. The readings are merged with any previous readings taken at this site.
- Reporting and printing facilities to allow sampled data to be used in word processor or spreadsheet generated reports.

Site Manager is available as a DOS (text) based windowing application with pull down menus and full support for a mouse.

6.2 Site Manager Program and Configuration Files

The following is a typical example of files supplied on the Site Manager disk.



The list will vary according to which configuration options are currently available. As standard all files are supplied so that there should be no need to obtain a new disk should the LMSx be upgraded at a later date.

The table below describes the function of the various configuration options.

- *Edit BH Info* Not available in this version, this menu entry will allow a bore hole code in a site edit window to be changed.

- *Transfer*
 - *To LMS (F2)* Available when the disk directory window has the input focus and a site is selected, or a site edit window has the focus. This item causes the site setup information (site name and bore hole codes) to be transferred to the LMS instrument's memory.
 - *From LMS (F3)* Available when the disk directory window has the input focus and a site is selected, or a site edit window has the input focus. This item causes readings stored in the LMS instrument's memory to be transferred to the computer (disk).

- *Window*
 - *Cascade* This menu option causes all displayed windows (directories and site editors) to be displayed in a cascaded fashion.
 - *Tile* This menu option causes all displayed windows (directories and site editors) to be displayed on the screen in a tiled fashion.
 - *Size/Move (CTRL+F5)* This menu option allows the currently focused window to be moved or re-sized. After selecting this option, the selected window will move when the cursor keys are pressed, and will change size if shift is held whilst pressing the cursor keys. Press the **Enter** key to confirm changes and end this mode, or the **Esc** key to cancel the changes and end the mode.
 - *Next (F6)* This menu option causes the next window in sequence to be selected. The selected window will be brought to the top of the window stack, and will have the focus.
 - *Zoom (F5)* This menu option causes the selected window to be toggled between full size (as large as the display) and its previous (non zoomed) size.

7.0 Field Operation

7.1 Zero Check

On arrival at site check that the instrument display reads correctly when sampling air. If there is a residual non-zero reading on the CH₄ or CO₂ channels or the O₂ channel is not correct then switch the unit off and perform a calibration self check. This done by holding down the '0'

key whilst switching the unit on. It is preferable to perform this check after giving the unit approximately 5 minutes to warm up.

7.2 Gas Sampling

The LMSx should always be operated using an external filter of the type supplied. This PTFE membrane filter will remove aerosol droplets of water and will totally block water liquid should any be accidentally sucked up from the bore hole. These filters have a relatively long lifetime (up to two months) but care should be taken to keep the "wet" side of the filter downstream from the analyser. Dirty or muddy water sucked into the filter will partially block it and eventually cause flow problems and it is best to renew the filter.

Internal condensation is detected by the LMSx and is shown on the display as 'Warning Contamination'. Should this occur try renewing the external filter immediately or try an additional filter. Condensation problems are minimised by keeping the analyser temperature as high as is practical. The analyser does 'self heat' by approximately 5°C if left switched on for 10 minutes or more and this improves its immunity to condensation greatly.

7.3 Pressure Measurements

The LMSx has an internal absolute pressure transducer connected to the gas outlet port. This is principally used to record atmospheric pressures.

7.4 Differential Pressure and Flow Measurement

An optional differential pressure transducer can be fitted between the inlet and outlet ports. This measures the pressure difference between the inlet and outlet port. Pressing the zero key ('0') zero's the differential pressure display if required.

By using the inlet port alone whilst the outlet is open to atmosphere suction may be measured directly.

Alternatively the LMSx to be connected across the measurement ports of Pitot tubes and orifice plates (Static and dynamic pressure tapings.) so that the differential pressure reading obtained is an indication of gas flow. The gas sample can be pumped through these measurement ports and a full set of results stored.

The pressure transducer readings are displayed on the screen and are constantly updated all the time that the sample pump is NOT running. At the moment the sample pump is switched on the latest pressure values are maintained on the screen whilst the gas sample is drawn into the analyser. These values are maintained for several seconds after the pump is switched off.

The sequence for measurement should be;

1. Zero pressure transducer
2. Connect to gas sample point
3. Wait for pressure reading to stabilise
4. Start sample pump
5. Wait for gas readings to stabilise
6. Store or note all readings
7. Switch off pump

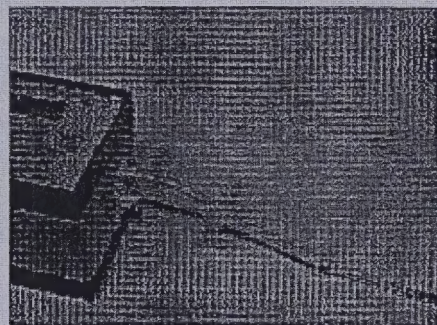
7.5 Low Range Flow and Pressure Measurements

1. Break the sample line at the in line quick release connection and then connect the sample pipe directly to the bottom connector on the LMSx as shown below.



NOTE: During measurement of low flow rates there must be no gas filter in line. This would impede any flow and make the results inaccurate. For accurate pressure measurements the sample line should be between 0.5 and 1m long with a 6 mm bore. Extreme care must be exercised to prevent ingress of particles or moisture when connected in this configuration.

2. Use the left or right arrow keys to select the flow and pressure screen if necessary.
3. Press the Confirm key to make the readings active. Flow and pressure readings will be displayed on the screen.
4. When you are happy with the flow rates and pressure readings press the cancel key to freeze the current values.
5. Press the right arrow key to move to the gas sampling screen
NOTE: Pressing the right arrow key alone will perform both functions (4. and 5.) simultaneously.
6. Reconnect the sample pipe as shown below making use of the PTFE filter



7. Press the pump key to draw a sample of gas from the bore hole. The analysed gas readings will be displayed on the screen.
8. Use the store function to save all of the readings (Flow pressure and gas) or write them down.

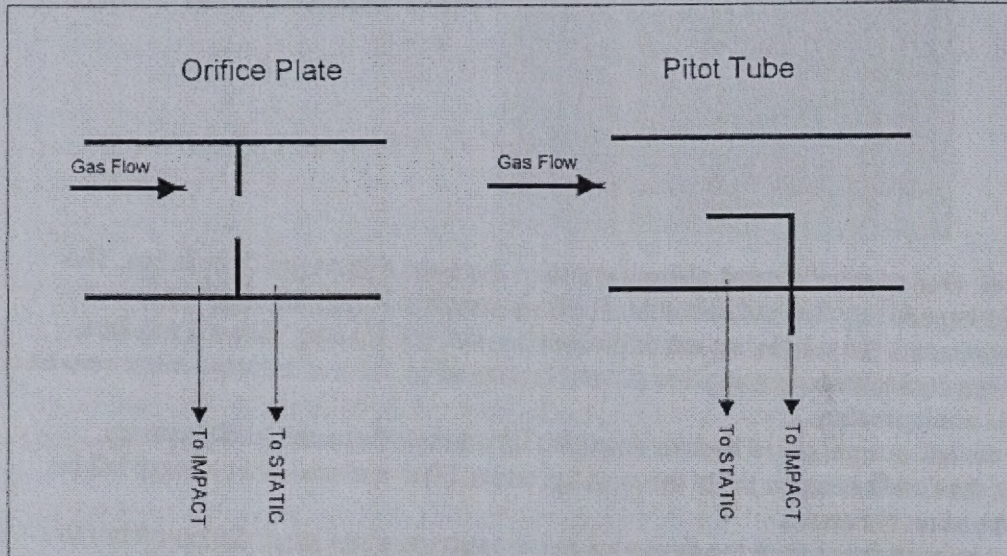
7.6 Temperature Measurements

Connect the optional temperature probe into the connector on the front panel of the LMSx and the temperature channel will automatically display the current probe temperature. The type supplied is for general measurement of air temperature, ground temperature, bore hole temperature etc.

7.7 Extraction Flow Measurement - LMSx +F

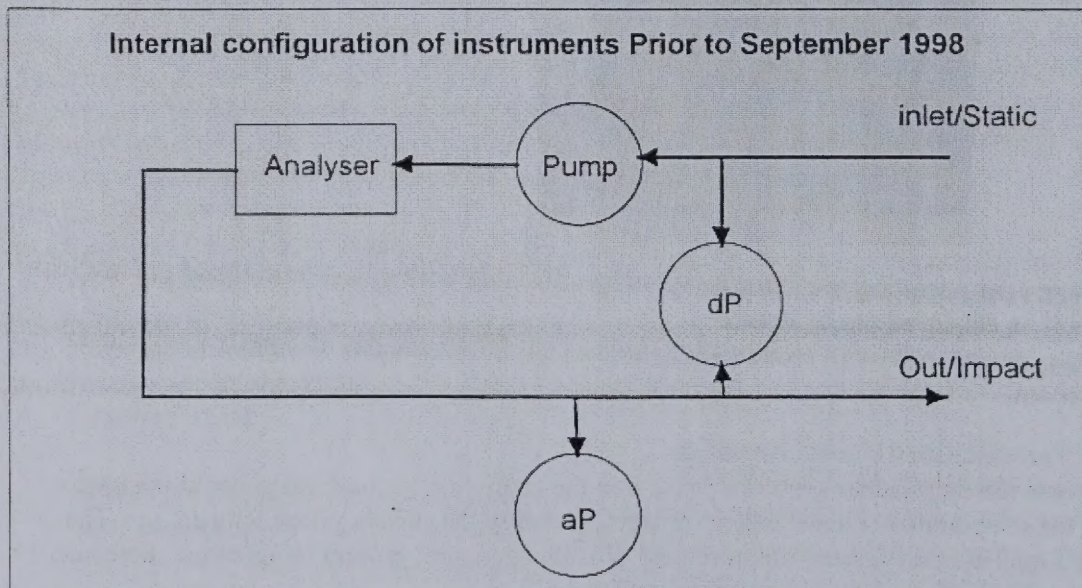
7.7.1 Well Head Requirements

The top port of the instrument, the inlet (Static) port, is connected to the sample pipe with in line PTFE filter. The bottom (Impact) port is connected to a sample pipe with no filters. The diagrams below show the connections to Orifice plates and Pitot tube flow devices.



TIP When connecting to a well head in the field and the connections are unclear or ambiguous connect the pipes first one way then the other. The correct way around will always yield the highest value of dP (ignore the sign of dP).

7.7.2 LMSx +F Prior to September 1998



A differential pressure transducer (dP) is fitted between the inlet (Static) and outlet (Impact) ports. This measures the pressure difference between the inlet and outlet port. The LMSx can now be connected across the measurement ports of Pitot tubes and orifice plates (Static and dynamic pressure tapings). The differential pressure reading obtained are now used as an indication of gas flow. The gas sample is pumped through these measurement ports and a full set of results stored.

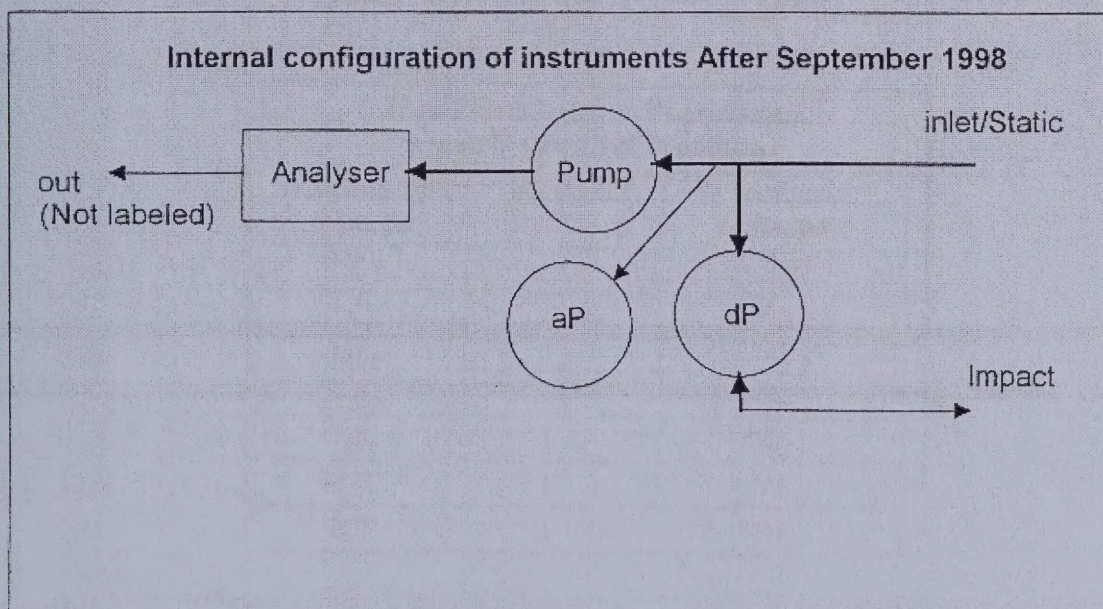
The measurement sequence is as follows;

1. Make sure the instrument flow parameter settings are correct for the well head to be measured.
See section on **Instrument Set Up**.
2. Make sure instrument is not connected to the wellhead
3. Press the next key to switch to the flow readings screen and press the "Zero" key to zero the pressure readings. dp and sP should now read zero.
4. Connect the inlet (Static) port to the well head using the sample pipe with in line PTFE filter.
5. Press the next key to switch to the gas readings screen. Press Pump to sample gas concentrations.
6. Switch off pump and connect the out (Impact) port to the wellhead using the remaining sample line.
7. Press the next key to switch to the flow readings screen and flow readings will be displayed.
8. **IMPORTANT** If the gas readings are to be re sampled the connection to the out (impact) port must be removed.

7.7.3 LMSx +F After September 1998

The internal configuration of sensors was changed from September 1998 to allow the field procedure to be simplified. The main elements are as explained above but the analyser is no longer subject to the full suction of the extraction system..

The well head requirements remain unchanged.



The measurement sequence is as follows;

1. Make sure the instrument flow parameter settings are correct for the well head to be measured.
See section on **Instrument Set Up**.
2. Make sure instrument is not connected to the wellhead
3. Press the next key to switch to the flow readings screen and press the "Zero" key to zero the pressure readings. dp and sP should now read zero.
4. Connect the inlet (Static) port to the well head using the sample pipe with in line PTFE filter.
5. Connect the Impact port to the wellhead using the remaining sample line.
6. Press the next key to switch to the gas readings screen. Press Pump to sample gas concentrations.
7. Switch off pump.
8. Press the next key to switch to the flow readings screen and flow readings will be displayed.
9. The gas readings may now be re sampled by switching back to the gas readings screen (press next key) and starting the pump then switch back to flow readings screen and so on.

7.7.4 Well Head Calibration Data

The following tables give LMSx flow device settings for some known well heads;

LFG&E Orifice Plate Well Heads LMSx Flow Device Values		
Pipe Id (Inches)	Orifice (Inches)	C ₀ value
1.943	0.6	0.48
1.943	1	0.486
1.943	1.4	0.484
1.943	1.5	0.478
3.682	1	0.48
3.682	1.5	0.482
3.682	2	0.485
3.682	2.5	0.484

Landtech Pitot Tube Well Heads LMSx Flow Device Values		
Accuflow Wellhead	K Factor	Pipe Diameter (cm)
1V	1	3.3
1H	1	3.3
2V	1	4.4
2H	1	4.5
3V	1	7.6
3H	1	7.6

Methane Monitoring Field Data

Facility: Unified Disposal District Landfill

License #: 389

Date: _____ Time: _____

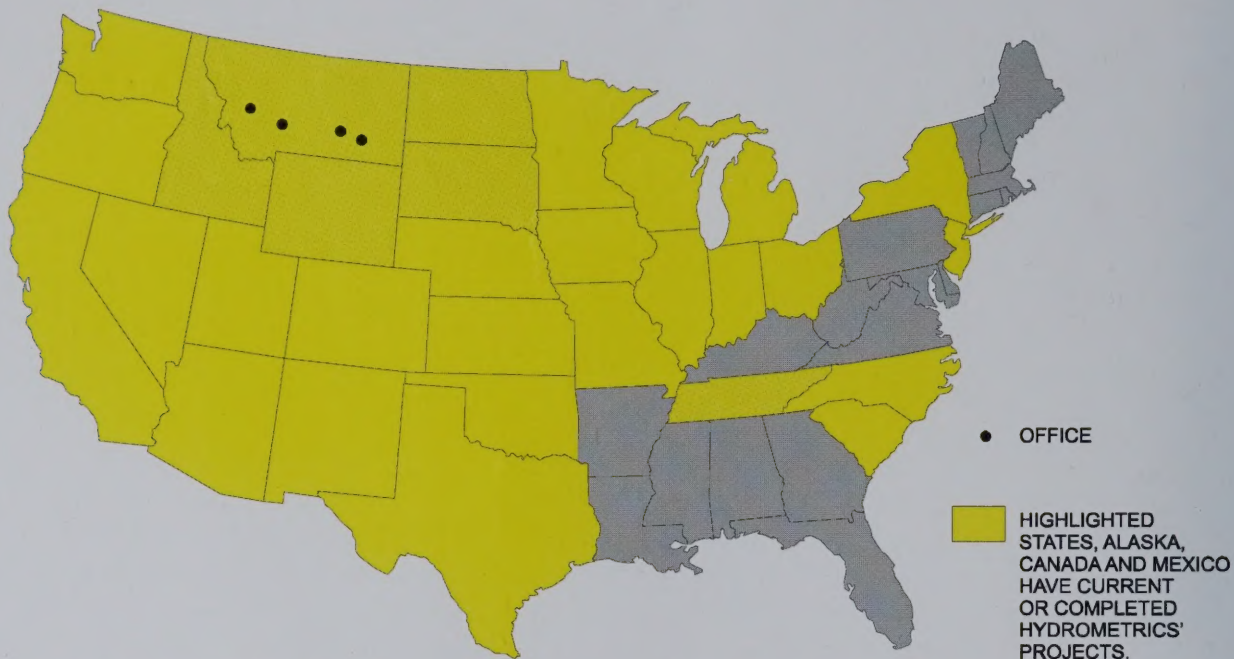
Sampler:

Air Temperature: _____

Other Weather Conditions:

[illegible]

NOTES:



HYDROMETRICS, INC. MONTANA OFFICES

HELENA (Corporate)
3020 Bozeman Avenue
Helena, MT 59601
Phone: (406) 443-4150
FAX: (406) 443-4155

BILLINGS
5602 Hesper Road
Billings, MT 59106
Phone: (406) 656-1172
FAX: (406) 656-8912

MISSOULA
667 East Beckwith
Missoula, MT 59801
Phone: (406) 721-8243
FAX: (406) 542-2619

COLSTRIP
Phone: (406) 656-8305
Fax: (406) 656-8912